

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents  
 United States Patent and Trademark  
 Office  
 Box PCT  
 Washington, D.C. 20231  
 ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

<b>Date of mailing</b> (day/month/year) 01 November 1999 (01.11.99)	
<b>International application No.</b> PCT/GB99/00765	<b>Applicant's or agent's file reference</b> DIH/P99466WO
<b>International filing date</b> (day/month/year) 15 March 1999 (15.03.99)	<b>Priority date</b> (day/month/year) 13 March 1998 (13.03.98)
<b>Applicant</b> ECCLESTON, William et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

24 September 1999 (24.09.99)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer S. Mafla Telephone No.: (41-22) 338.83.38
---	--

## PATENT COOPERATION TREATY

5

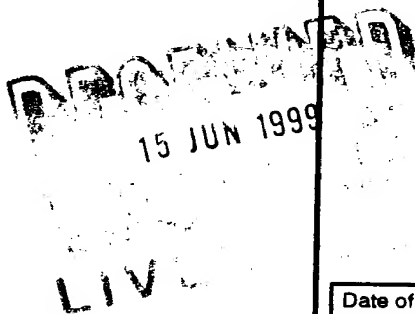
From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL SEARCH REPORT  
OR THE DECLARATION

(PCT Rule 44.1)

To:

W.P. THOMSON & CO.  
CHURCH STREET  
LIVERPOOL L1 3AB  
UNITED KINGDOMDate of mailing  
(day/month/year)

11/06/1999

Applicant's or agent's file reference

DIH/P99466W0

FOR FURTHER ACTION

See paragraphs 1 and 4 below

International application No.

PCT/GB 99/ 00765

International filing date  
(day/month/year)

15/03/1999

Applicant

THE UNIVERSITY OF LIVERPOOL et al.

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

**Filing of amendments and statement under Article 19:**

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

**When?** The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

**Where?** Directly to the International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland  
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority

European Patent Office, P.B. 5818 Patentlaan 2  
NL-2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Grietje Matthijs

## NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

### INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

#### What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

#### When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

#### Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

#### How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

#### What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

**NOTES TO FORM PCT/ISA/220 (continued)**

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:  
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers;  
claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:  
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:  
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or  
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:  
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

**"Statement under article 19(1)" (Rule 46.4)**

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

**It must be in the language in which the international application is to be published.**

**It must be brief, not exceeding 500 words if in English or if translated into English.**

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)." **1**

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

**Consequence if a demand for international preliminary examination has already been filed**

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

**Consequence with regard to translation of the international application for entry into the national phase**

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>DIH/P99466W0</b>	<b>FOR FURTHER ACTION</b> <small>see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.</small>	
International application No. <b>PCT/GB 99/ 00765</b>	International filing date (day/month/year) <b>15/03/1999</b>	(Earliest) Priority Date (day/month/year) <b>13/03/1998</b>
Applicant  <b>THE UNIVERSITY OF LIVERPOOL et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

**1. Basis of the report**

- a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of the sequence listing :



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ Certain claims were found unsearchable (See Box I).

3. ☐ Unity of invention is lacking (see Box II).

**4. With regard to the title,**



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

**5. With regard to the abstract,**



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

**6. The figure of the drawings to be published with the abstract is Figure No.**



as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.



None of the figures

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/00765

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 H01J1/30

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	(EP 0 399 299 A) (IBM) 28 November 1990 ✓ see page 3, line 48 - line 56; claims 13-18 see page 5, line 1 - line 12	1-3
X	(GB 2 233 334 A) (EXITECH LTD) 9 January 1991 see page 7, line 4 - line 12; claims 1,8	1
A	(WO 95 28742 A) (UNIAX CORP) (26 October 1995) see page 33 - page 35; claims 1,4,6; example 6	1
A	(EP 0 540 839 A) (MATSUSHITA ELECTRIC IND CO LTD) 12 May 1993 see claims 1,7	1
-/--		



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

**\* Special categories of cited documents :**

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*A\* document member of the same patent family

Date of the actual completion of the international search

25 May 1999

Date of mailing of the international search report

11/06/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

VAN DEN BULCKE, E

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 99/00765

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
A	ASANO T ET AL: "FIELD EMISSION FROM ION IRRADIATED PHOTORESIST" 15 June 1997 , JAPANESE JOURNAL OF APPLIED PHYSICS, VOL. 36, NR. 6B, PAGE(S) L818 - L820 XP000732171 see page L818 - page L820 ---	1
P,X	I.MUSA ET AL.: "ULTRA- LOW-THRESHOLD FIELD EMISSION FROM CONJUGATED POLYMERS" NATURE, vol. 395, 24 September 1998, pages 362-365, XP002103577 see page 362 - page 365 ---	1, 15
P,X	I.MUSA ET AL.: "ANALYSIS OF LOW THRESHOLD FIELD-EMISSION FROM CONJUGATED POLYMERS FOR DISPLAYS" INTERNATIONAL ELECTRON DEVICES MEETING, IEDM '98 TECHNICAL DIGEST, December 1998, pages 867-869, XP002103578 see page 867 - page 869 ---	1, 15
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 498 (E-1146), 17 December 1991 & <u>JP 03 216998 A</u> (RICOH CO LTD), 24 September 1991 see abstract -----	1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 99/00765

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0399299	A	28-11-1990	US 5198153 A	30-03-1993
			JP 2657956 B	30-09-1997
			JP 3088819 A	15-04-1991
			US 5721299 A	24-02-1998
			US 5202061 A	13-04-1993
			US 5200112 A	06-04-1993
GB 2233334	A	09-01-1991	NONE	
WO 9528742	A	26-10-1995	US 5563424 A	08-10-1996
			AU 2127895 A	10-11-1995
			EP 0755575 A	29-01-1996
EP 0540839	A	12-05-1993	JP 5087559 A	06-04-1993
			DE 69212113 D	14-08-1996
			DE 69212113 T	21-11-1996
			US 5353632 A	11-10-1994



# W.P. THOMPSON & Co

FOUNDED 1873

CHARTERED PATENT ATTORNEYS  
EUROPEAN PATENT ATTORNEYS  
EUROPEAN TRADE MARK ATTORNEYS

COOPERS BUILDING  
CHURCH STREET  
LIVERPOOL L1 3AB

PATENTS · TRADE MARKS · DESIGNS · COPYRIGHT

OUR REF. DH/RJB/hr/P99466WO

YOUR REF.

FEBRUARY 2000

REPLACEMENT PAGE Nos. 4,7 AND CLAIMS

for

PCT PATENT APPLICATION No. GB/99/00765

for

THE UNIVERSITY OF LIVERPOOL

**LONDON OFFICE:**  
CELCON HOUSE, 289-293 HIGH HOLBORN, LONDON WC1V 7HU.  
TEL: 020-7242 3524/020-7408 2174 TELEX: 268801 POLLAK G  
FAX: 020-7831 0134/020-7405 8607

**HULL OFFICE:**  
KINGS BUILDING, SOUTH CHURCH SIDE, HULL  
EAST YORKSHIRE HU1 1BB

**LETCHEWORTH OFFICE:**  
EASTCHEAP HOUSE, CENTRAL APPROACH, LETCHEWORTH,  
HERTFORDSHIRE SG8 3DS.  
TEL: 01462-682139 FAX: 01462-878775

**MUNICH OFFICE:**  
REITMORSTRASSE 18/1,  
D-80530 MUNICH, GERMANY

J. D. McCALL, B.Sc. Tech. CPA, EPA, RTMA  
W. J. A. BEEDON, MA, C.Eng., CPA, EPA, RTMA  
O. L. HUNTINGFORD, B.Sc. C.Eng. MICE, CPA, EPA, RTMA  
D. H. STRINGER, B.Sc. CPA, EPA, RTMA  
P. B. THOMPSON, B.Sc. CPA, EPA, RTMA  
C. T. STYLES, MA, C.Eng., FRD, C.Eng., MRSC, CPA, EPA, RTMA  
R. ACKROYD, B.Sc. FRD, C.Eng., MRSC, CPA, EPA, RTMA  
N. M. MAMLEY, B.Sc. CPA, EPA, RTMA  
A. J. A. WALKER, B.Sc. CPA, EPA, RTMA  
JACQUELINE O. FREEMAN, BA, C.Eng., CPA, EPA, RTMA  
JENNIFER M. MADDOX, BA, RTMA  
D. A. GILL, B.Eng. (Electrical Eng.), CPA, EPA, RTMA

Assisted by  
D. G. DOVEILLER, B.Sc. CPA, EPA, RTMA  
P. O. DICE, DCC, CPA, EPA, RTMA  
R. J. BARTLE, DCC, CPA

Consultants  
J. P. HINCHLEY, MA, C.Eng., CPA, EPA  
D. G. SEFTON, B.Sc. C.Eng., FRSC, CPA, EPA  
R. E. OLIVER, B.Sc. CPA, EPA  
A. T. RUSSELL, C.Eng., FRSC, CPA, EPA, RTMA  
R. M. GORE, B.Sc. Spac. CPA, EPA  
C. JONES, MA, C.Eng., CPA, EPA, RTMA  
I. JONES, B.Sc. CPA, EPA, RTMA  
P. K. TAYLOR, B.Sc. CPA, EPA

General Manager  
C. H. LAWTON  
Computer Systems Manager  
O. W. BRADLEY

TELEPHONE: 0151-709 8861  
INT. +44 151-709 3961

CABLES:  
PATENTS LIVERPOOL L1 3AB

DOCUMENT EXCHANGE  
DX 14150, LIVERPOOL

E MAIL:  
wpt@wpthompson-liverpool.co.uk

Website:  
www.wpt.co.uk

FAX: 0151-709 0182  
0151-708 8802  
INT. +44 151-709 0182  
INT. +44 151-708 8802

13

WO 99/48122

PCT/GB99/00765

- 4 -

of manufacture in suitable form for use in a field emission display.

In accordance with a first aspect of the present invention, there is provided a field emission cathode comprising polymer material forming a field emission surface.

The inventors have fortuitously (and most unexpectedly) discovered that polymer materials can be manufactured giving high electron emission. Polymer materials can be formed by known techniques into uniform cathodes, which may be large in area, and can be highly stable. Exclusion of oxygen is considered useful for the stability of the material.

It is particularly preferred that the polymer is a conjugated polymer material. Conjugated polymers typically have high density of free electrons. Most polymer films are p type with few free electrons; the substrate of the cathode can itself contribute electrons.

Such materials are known for other applications in electronics, which utilise semiconductor type properties of certain conjugated polymers. The usual applications proposed for conjugated polymers - eg. in light emitting structures, photocopiers, photodetectors and thin film transistors - do not require the material to have a low work function, and it is believed that this property of such materials has not hitherto been utilised. The present inventors have found that some such polymeric materials are capable of producing very high steady state field emission currents with the threshold field needed to initiate field emission being smaller than for any other so far reported.

It is especially preferred that the polymer material is a substituted

WO 99/48122

PCT/GB99/00765

- 7 -

the grid and a luminescent screen, wherein electrons are selectively emitted from the cathode under the influence of the grid and then accelerated onto the screen with sufficient energy to cause it to luminesce by the acceleration anode.

In accordance with a third aspect of the present invention, there is a method of fabricating a field emission cathode comprising forming a layer comprising polymer material on a substrate, the polymer material forming a field emission surface of the cathode.

The polymer material may be any of the polymer materials referred to above with respect to the first aspect of the invention.

Specific embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a graph of normalised or average field emission current density (on a logarithmic scale of  $A\text{cm}^{-2}$  on the vertical axis) against applied voltage for a cathode embodying the present invention;

Fig. 2a is a graph of normalised field emission current density from a cathode according to the present invention in  $A\text{cm}^{-2}$  and a logarithmic scale on the vertical axis against normalised applied electric field on the horizontal axis, measured in volts per  $\mu\text{m}$ . Results are shown for three anode-cathode spacings, the left-most line being for a spacing of  $27\mu\text{m}$ , the middle line for  $47\mu\text{m}$  and the right-most line for  $130\mu\text{m}$ ;

Fig. 2b is a graph of normalised field emission current density from a cathode according to the present invention in  $A\text{cm}^{-2}$  and a logarithmic scale on the vertical

WO 99/48122

PCT/GB99/00765

- 18 -

CLAIMS

1. A field emission cathode comprising polymer material forming a field emission surface.
2. A field emission cathode as claimed in claim 1, wherein the polymer material comprises a conjugated polymer.
3. A field emission cathode as claimed in any preceding claim wherein the polymer material is a substituted polythiophene.
4. A field emission cathode as claimed in any preceding claim wherein the polymer material comprises a polyalkylthiophene.
5. A field emission cathode as claimed in any preceding claim wherein the polymer material comprises poly-3-octylthiophene.
6. A field emission cathode as claimed in any preceding claim wherein the polymer material is formed as a layer on a substrate.
7. A field emission cathode as claimed in claim 6, wherein the polymer material layer is formed from a polymer solution which is distributed on the substrate, the solvent being evaporated during manufacture to leave behind the polymer layer.
8. A field emission cathode as claimed in claim 7, wherein the solvent is evaporated under vacuum.
9. A field emission cathode as claimed in claim 7 or claim 8, wherein the surface of the polymer layer comprises voids which are formed by solvent evaporation.

WO 99/48122

PCT/GB99/00765

- 19 -

10. A field emission cathode as claimed in any of claims 1 to 8, wherein the surface of the polymer material is shaped by use of a mould.

11. A field emission cathode as claimed in claim 10 wherein the moulded shape of the polymer material surface comprises projections which promote field emission.

12. A field emission cathode as claimed in any preceding claim, wherein the polymer material is doped with an electron donor material.

13. A field emission display comprising a field emission cathode as claimed in any preceding claim.

14. A field emission display device as claimed in claim 13, comprising a first anode separated from the cathode such as to be capable of causing field emission therefrom, a second anode positioned beyond the first anode and a luminescent screen, wherein electrons are selectively emitted from the cathode under the influence of the first anode then accelerated onto the screen with sufficient energy to cause it to luminesce by the second anode.

15. A method of fabricating a field emission cathode comprising forming a layer comprising polymer material on a substrate, the polymer material forming a field emission surface of the cathode.

16. A method as claimed in claim 15, wherein a polymer solution is distributed on the substrate and the solvent is evaporated to leave behind the polymer layer.

17. A method as claimed in claim 16, wherein the solvent is evaporated under

WO 99/48122

PCT/GB99/00765

- 20 -

vacuum.

18. A method as claimed in any of claims 16 to 18, comprising the further step of shaping the surface of the polymer material by use of a mould.

## PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)



Applicant's or agent's file reference P99466WO	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/GB99/00765	International filing date (day/month/year) 15/03/1999	Priority date (day/month/year) 13/03/1998
International Patent Classification (IPC) or national classification and IPC H01J1/30		
Applicant THE UNIVERSITY OF LIVERPOOL et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 24/09/1999	Date of completion of this report 10.04.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Zuccatti, S Telephone No. +49 89 2399 2710 

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB99/00765

**I. Basis of the report**

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

**Description, pages:**

1-3,5,6,8-17	as originally filed			
4,7	as received on	28/02/2000	with letter of	23/02/2000

**Claims, No.:**

1-17	as received on	28/02/2000	with letter of	23/02/2000
------	----------------	------------	----------------	------------

**Drawings, sheets:**

1/6-6/6	as originally filed
---------	---------------------

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB99/00765

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes: Claims 1-17
	No: Claims
Inventive step (IS)	Yes: Claims 1-17
	No: Claims
Industrial applicability (IA)	Yes: Claims 1-17
	No: Claims

2. Citations and explanations

**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:

**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB99/00765

1. Novelty:

The field emitter described in D1=Asano et al.: "Field Emission From a Photoresist" (Jpn. Appl. Phys. Vol. 36, 1997) is considered as the closest prior art concerning the field emission cathode according to the present claim 1. The field emitter described in D1 is based on photoresist material. Electroconductivity of the photoresist layer is obtained with argon ion implantation.

The present subject-matter (see independent claims 1 and 14) differs from the known field emitter in that the emissive material is a conjugated polymer.

The subject-matter of claims 1 and 14, and of the respective dependent claims, is therefore new (Article 33.2 PCT).

2. Inventive step:

D1 mentions that photoresist may be carbonized by ion irradiation, causing an appreciable electroconductivity, it is unclear, however, whether such photoresist material may be used as field emitter material. The composition of the photoresist is not given in D1. In any case, there is no suggestion in D1 to use conjugated polymers.

D2=EP-A-540839 discloses a probe for an scanning tunnelling microscope. Figure 1b shows a monolayer of a conjugated polymer (polythiophene) bonded to a tungsten tip (1). This is, however, clearly not a field emission cathode according to the terminology used in the present technical field. There is no indication to use the mentioned material in a field emission cathode.

D3=WO-A-95/28742 shows the use of conductive polymer grids in triode structures. The polymer itself serves to control the charge carrier transport (see eg. page 14, lines 27-34; page 27, line 29, to page 28, line 8). The cathode, however, is a metallic conductor (see eg. page 16, lines 24-34; page 23, line 23, to page 25, line 21; page 36, lines 15-27). The discussion

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB99/00765

in Example 6 (page concerning field emission is concerns charge injection into an active material in contact with the polymer rather than emission into the vacuum (see page 7, lines 19-25). It is considered that this does not indicate that the conductive polymer could be used as a field emitter cathode.

The following documents are less relevant:

D4=EP-A-0399299 is concerned with electroconductive polymeric materials, a part of which are conjugated polymeric materials. However, there is no indication to use these materials in field emission devices. D2 proposes that the polymers may be used as conductive layers to prevent charge build-up or for electromagnetic shielding (see eg. page 3, lines 6-17). D5=GB-A-2233334 describes a field emission cathode obtained by irradiating an electroconductive polymer layer with a laser so as to produce a rough surface with a high density of cone-shaped erosions. The polymer is apparently not used as emitter material, because its surface is metallized in order to obtain a field emitting surface (see page 7, 2nd paragraph).

None of the cited documents suggests the use of a conjugated polymer as emissive layer in a field emission cathode. Therefore, claims 1 and 14, and claims 2-13, 15-17, dependent thereon, involve an inventive step (Article 33.3 PCT).

3. Industrial applicability of the claimed subject-matter is obvious (Article 33.4 PCT).

4. The relevant state of the art (D1) should be cited in the description (Rule 5.1.a.ii PCT).

\*\*\*\*\*

M 28.02.00

of manufacture in suitable form for use in a field emission display.

In accordance with a first aspect of the present invention, there is provided a field emission cathode comprising conjugated polymer material forming a field emission surface.

The inventors have fortuitously (and most unexpectedly) discovered that polymer materials can be manufactured giving high electron emission. Polymer materials can be formed by known techniques into uniform cathodes, which may be large in area, and can be highly stable. Exclusion of oxygen is considered useful for the stability of the material.

Conjugated polymers typically have high density of free electrons. Most polymer films are p type with few free electrons; the substrate of the cathode can itself contribute electrons.

Such materials are known for other applications in electronics, which utilise semiconductor type properties of certain conjugated polymers. The usual applications proposed for conjugated polymers - eg. in light emitting structures, photocopiers, photodetectors and thin film transistors - do not require the material to have a low work function, and it is believed that this property of such materials has not hitherto been utilised. The present inventors have found that some such polymeric materials are capable of producing very high steady state field emission currents with the threshold field needed to initiate field emission being smaller than for any other so far reported.

It is especially preferred that the polymer material is a substituted

M 28.02.00

the grid and a luminescent screen, wherein electrons are selectively emitted from the cathode under the influence of the grid and then accelerated onto the screen with sufficient energy to cause it to luminesce by the acceleration anode.

In accordance with a third aspect of the present invention, there is a method of fabricating a field emission cathode comprising forming a layer comprising conjugated polymer material on a substrate, the polymer material forming a field emission surface of the cathode.

The polymer material may be any of the polymer materials referred to above with respect to the first aspect of the invention.

Specific embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a graph of normalised or average field emission current density (on a logarithmic scale of  $Acm^{-2}$  on the vertical axis) against applied voltage for a cathode embodying the present invention;

Fig. 2a is a graph of normalised field emission current density from a cathode according to the present invention in  $A cm^{-2}$  and a logarithmic scale on the vertical axis against normalised applied electric field on the horizontal axis, measured in volts per  $\mu m$ . Results are shown for three anode-cathode spacings, the left-most line being for a spacing of  $27\mu m$ , the middle line for  $47\mu m$  and the right-most line for  $130\mu m$ ;

Fig. 2b is a graph of normalised field emission current density from a cathode according to the present invention in  $A cm^{-2}$  and a logarithmic scale on the vertical

14.02.00

18

CLAIMS

1. A field emission cathode comprising conjugated polymer material forming a field emission surface.
2. A field emission cathode as claimed in claim 1 wherein the polymer material is a substituted polythiophene.
3. A field emission cathode as claimed in any preceding claim wherein the polymer material comprises a polyalkylthiophene.
4. A field emission cathode as claimed in any preceding claim wherein the polymer material comprises poly-3-octylthiophene.
5. A field emission cathode as claimed in any preceding claim wherein the polymer material is formed as a layer on a substrate.
6. A field emission cathode as claimed in claim 5, wherein the polymer material layer is formed from a polymer solution which is distributed on the substrate, the solvent being evaporated during manufacture to leave behind the polymer layer.
7. A field emission cathode as claimed in claim 6, wherein the solvent is evaporated under vacuum.
8. A field emission cathode as claimed in claim 6 or claim 7, wherein the surface of the polymer layer comprises voids which are formed by solvent evaporation.
9. A field emission cathode as claimed in any of claims 1 to 7, wherein the surface of the polymer material is shaped by use of a mould.

M 28.02.00

19

10. A field emission cathode as claimed in claim 9 wherein the moulded shape of the polymer material surface comprises projections which promote field emission.

11. A field emission cathode as claimed in any preceding claim, wherein the polymer material is doped with an electron donor material.

12. A field emission display comprising a field emission cathode as claimed in any preceding claim.

13. A field emission display device as claimed in claim 12, comprising a first anode separated from the cathode such as to be capable of causing field emission therefrom, a second anode positioned beyond the first anode and a luminescent screen, wherein electrons are selectively emitted from the cathode under the influence of the first anode then accelerated onto the screen with sufficient energy to cause it to luminesce by the second anode.

14. A method of fabricating a field emission cathode comprising forming a layer comprising conjugated-polymer material on a substrate, the polymer material forming a field emission surface of the cathode.

15. A method as claimed in claim 14, wherein a polymer solution is distributed on the substrate and the solvent is evaporated to leave behind the polymer layer.

16. A method as claimed in claim 15, wherein the solvent is evaporated under vacuum.

14.25.02.00

20

17. A method as claimed in claim 15 or claim 16, comprising the further step of shaping the surface of the polymer material by use of a mould.



## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>DIH/P99466W0</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 99/ 00765</b>	International filing date (day/month/year) <b>15/03/1999</b>	(Earliest) Priority Date (day/month/year) <b>13/03/1998</b>
Applicant <b>THE UNIVERSITY OF LIVERPOOL et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.



None of the figures.

## INTERNATIONAL SEARCH REPORT

International Application No.

GB 99/00765

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 H01J1/30

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 399 299 A (IBM) 28 November 1990 see page 3, line 48 - line 56; claims 13-18 see page 5, line 1 - line 12 ---	1-3
X	GB 2 233 334 A (EXITECH LTD) 9 January 1991 see page 7, line 4 - line 12; claims 1,8 ---	1
A	WO 95 28742 A (UNIAx CORP) 26 October 1995 see page 33 - page 35; claims 1,4,6; example 6 ---	1
A	EP 0 540 839 A (MATSUSHITA ELECTRIC IND CO LTD) 12 May 1993 see claims 1,7 ---	1
	--- -/--	

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&amp;" document member of the same patent family

Date of the actual completion of the international search

25 May 1999

Date of mailing of the international search report

11/06/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040; Tx. 31 651 epo.nl.  
Fax: (+31-70) 340-3016

Authorized officer

VAN DEN BULCKE, E

## INTERNATIONAL SEARCH REPORT

International Application No.

GB 99/00765

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ASANO T ET AL: "FIELD EMISSION FROM ION IRRADIATED PHOTORESIST" 15 June 1997 , JAPANESE JOURNAL OF APPLIED PHYSICS, VOL. 36, NR. 6B, PAGE(S) L818 - L820 XP000732171 see page L818 - page L820 ----	1
P,X	I.MUSA ET AL.: "ULTRA- LOW-THRESHOLD FIELD EMISSION FROM CONJUGATED POLYMERS" NATURE, vol. 395, 24 September 1998, pages 362-365, XP002103577 see page 362 - page 365 ----	1,15
P,X	I.MUSA ET AL.: "ANALYSIS OF LOW THRESHOLD FIELD-EMISSION FROM CONJUGATED POLYMERS FOR DISPLAYS" INTERNATIONAL ELECTRON DEVICES MEETING, IEDM '98 TECHNICAL DIGEST, December 1998, pages 867-869, XP002103578 see page 867 - page 869 ----	1,15
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 498 (E-1146), 17 December 1991 & JP 03 216998 A (RICOH CO LTD), 24 September 1991 see abstract -----	1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

/GB 99/00765

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0399299	A	28-11-1990	US 5198153 A	30-03-1993
			JP 2657956 B	30-09-1997
			JP 3088819 A	15-04-1991
			US 5721299 A	24-02-1998
			US 5202061 A	13-04-1993
			US 5200112 A	06-04-1993
GB 2233334	A	09-01-1991	NONE	
WO 9528742	A	26-10-1995	US 5563424 A	08-10-1996
			AU 2127895 A	10-11-1995
			EP 0755575 A	29-01-1996
EP 0540839	A	12-05-1993	JP 5087559 A	06-04-1993
			DE 69212113 D	14-08-1996
			DE 69212113 T	21-11-1996
			US 5353632 A	11-10-1994